Study of high DC voltage breakdown between stainless steel electrodes separated by long vacuum gaps

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Abstract:

High voltage (HV) insulation across a single gap in vacuum and low-pressure gas is a critical issue in relation to the development and realization of the electrostatic accelerator for the ITER neutral beam injector (NBI) (Toigo et al 2017 New J. Phys. 19 085004). The present paper describes and analyzes the recent experimental results obtained at the High Voltage Padova Test Facility (HVPTF), the laboratory aimed at supporting the development of the prototype for the ITER NBI (De Lorenzi et al 2011 Fusion Eng. Des. 86 742–5). A voltage up to 800kVDC was achieved in the HVPTF during the experimental campaigns with a sphere-plane configurations having variable gap length (from 30 to 150 mm) and pressure ranging from high vacuum (10–7 mbar) to 10–3 mbar in argon. Such an experimental campaign represents one of the few examples where voltages higher than 500–550 kV DC are sustained by a single vacuum gap between electrodes (Rohrbach 1971 CERN Report 71-5) and therefore constitutes additional experience to improve the knowledge of voltage holding across large vacuum gaps. The results in high vacuum indicate that at the beginning of voltage conditioning the breakdown events occur at the same cathodic electric field irrespective of the electrode geometry. However, after sufficient conditioning time, the breakdown voltage distribution seems to depend also on the electric field at the anode and on the total voltage between electrodes. A benchmark between a numerical tool previously developed to predict the voltage holding in high vacuum (voltage holding prediction model, VHPM (Pilan et al 2011 Fusion Eng. Des. 86 742–5)) and the experimental results is also reported and discussed.